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Definition of an Approach for the Development of Product-Service Systems

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Abstract

The concept of Product-Service Systems (PSS) allows companies to offer customer focused products by matching classical product concepts with service concepts. This results in new challenges for the development phase. This publication aims to deduce and discuss a generic PSS development process. Therefore product and service development processes were analyzed and combined to a PSS development process. In its development, a PSS confronts the developer with new challenges. Most of these challenges can be assigned to a certain phase in the development, while some of them appear in the entire life-cycle of a PSS. During this research, it was the aim to match the detected challenges of PSS with methods that have been developed for supporting PSS development. The PSS development process, its challenges and methods are finally applied on a PSS case.

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Keywords: product-service system, development process, supporting methods, problems and challenges, design methodologies

1. Introduction

In most developed countries, the service sector has a share of 70-80% of the entire gross domestic product, so even ordinary manufacturers experience an increasing need to understand and integrate services in the form of Product-Service Systems (PSS) [1]. PSSs provide a possibility to differentiate their own products from competitors who simply offer lower priced ones [2]. A PSS is a strategy focused on the customer by aiming to increase value via understanding the customer's needs in detail to completely fulfill the customer's demands [3]. For this reason, qualitative satisfaction of the customer is desired, rather than quantitative sufficiency of the product. This is achieved, using products with more values supplied by service contents rather than just by materialistic ones [4, 5].

During the development of a PSS, products and services have to be developed within an integrated design process. According to Maussang et al.[6] and Marques et al. [3], at the moment, no methodology could be found to support the development of a Product-Service System [3, 6]. Furthermore, it is necessary to develop a methodology that is more applicable to the industry than the current ones [3]. During the research for this paper, current approaches for PSS-development were analyzed, which confirmed the statements of Maussang et al. [6] and Marques et al. [3]. Since there were no sufficient approaches available, current product development processes and service development processes were searched, compared and combined to the Approach for the Development of Product-Service Systems. This approach was extended by laying out occurring problems or challenges in the development process of PSSs and methods that can solve these problems or challenges. It was also evaluated by the development of a use case.

The paper is structured as follows: in the second section, the literature review of PSS-development is presented. In the third section, the Approach for the Development of Product-Service Systems is introduced and its creation is clarified. The approach is extended by problems or challenges and methods for the development in the fourth section. Afterwards, the approach is evaluated with a use case, which is followed by a discussion and an outlook.

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2. Literature Review of PSS-Development

The research for this paper began with a search for Product-Service Systems in the search engines “Web of Science”, “Google Books”, “Google Scholar” and “TUM Library”. The aim of this search was to determine state of the art in PSS, state of the art meaning the definition of a PSS and current development processes. In table 1 some of the references that are used in this paper are listed. The search offered many other references that were checked and regarded as unsuitable or were not available in the TUM Library. The references were extended by existing references at the Institute of Product Development. This literature review serves an example for all the conducted literature reviews, but does not show their volume.

Table 1. The results of the search for PSS.

Search Engine	Keyword	Viewed Hits	Hits, used in this Paper
Web of Science	Product-Service System (topic)	30 of 689	Baines et al. [2]; Marques et al. [3]; Vasantha et al. [5]
Google Books	Product Service Systems	30 of 247000	-
Google Scholar	Product service system	30 of 3310000	Mont [7]; Goedkoop et al. [8]; Maussang et al. [6]; Meier et al. [9]
TUM Library	product service system	30 of 2125	-
	product-service-system	16 of 16	Sakao and Shimomura [10]; Shimomura and Arai [4]

In literature, many definitions for the term “Product-Service System” are available. Goedkoop et al. [8] coined the term Product-Service System. Table 2 shows the definitions that were considered as most appropriate during the literature review. These definitions are combined to the definition used in this paper: “A *PSS* is defined as a marketable set of products and services capable of jointly fulfilling a user’s need by adding value throughout the product-service life-cycle.”

Table 2. Collection of different definitions for PSSs.

Definition of a Product-Service System	Reference
A Product-Service System is a marketable set of products and services capable of jointly fulfilling a user’s need.	Goedkoop et al. [8]
A Product-Service System offers to break the link between value delivered to the user and the amount of physical material needed to create that value.	Baines et al. [2]
A Product-Service System is combining products and services, as a whole system that offers added value throughout their product-service life-cycle.	Marques et al. [3]
A Product-Service System is a system of products, services, supporting networks and infrastructure that is designed to be competitive, to satisfy customer needs and to have a lower environmental impact than traditional business models.	Mont [7]

At the time of the search for PSS-development processes, no secured development process could be found. Therefore, it is necessary to create a methodology to support the development of a Product-Service System [6]. Sakao and Shimomura [10] stress that it is true that many methods dealing with service in eco-design exist. However, very few have established a method that pursues providing a high value for customers by designing services and products in parallel [10]. These statements in literature lead to the conclusion that there is a certain need for an Approach for the Development of Product-Service Systems.

3. Approach for the Development of Product-Service Systems

In this chapter the literature review and the creation process of the Approach for the Development of Product-Service Systems is shown. The whole approach is presented and the single development steps are explained.

3.1. Literature Review of Product and Service Development Processes

Since the first literature review did not lead to a sufficient development process for Product-Service Systems, a second literature review was conducted that aimed to determine product development processes and service development processes. The results are shown in table 3. These development processes were compared and combined to an Approach for the Development of Product-Service Systems.

Table 3. The selected development processes.

Product Development Processes	Service Development Processes
Product Development Process (Feldhusen and Grote [11])	Service Development Process (Meiren and Barth [12])
Development Process (Ulrich and Eppinger [13])	Knowledge-based Development Process for Services (Wildemann [14])
Stage-Gate System for Major Product Development Projects (Kahn [15])	The Lifecycle of a Service (Hepperle [16])
Stages of Life of a Product (Ehrlenspiel and Mehrkamm [17])	Planning Cycle for Successful New Service Integration (Tax and Stuart [18])
Munich procedural model (Lindemann [19])	

3.2. Deriving the Approach from the Development Processes

As an example for the entire process of deriving the approach, two development processes are highlighted to illustrate the origin of the phases. Figure 1 shows the Stages of Life of a Product according to Ehrlenspiel and Mehrkamm [17] and the Lifecycle of a Service as described by Hepperle [16] in parts.

During the deriving process, the phases of the five product development and the four service development processes were compared to each other and examined for similarities and contradictions. They had between five and nine phases. The resulting approach could be divided into five phases and this deriving process is shown exemplarily with the phase “Planning”.

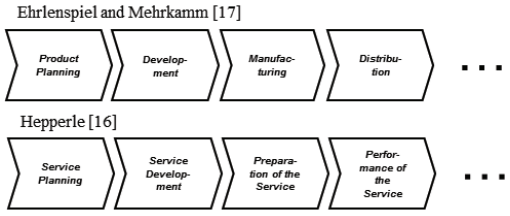

Fig. 1. The development processes after Ehrlenspiel and Mehrkamm [17](Product) and Hepperle [16](Service).

The first phase of the Stages of Life of a Product after Ehrlenspiel and Mehrkamm [17] is called “Product Planning”, while the first phase of the Lifecycle of a Service after Hepperle [16] is called “Service Planning”. This leads to the conclusion that the first phase in the development of a PSS should also be a Planning phase. When the wording of the phases were determined, the actions were also determined.

This was conducted in a way that the actions of similar phases, in this example the planning phases of the development processes, were compared to each other and the most suitable actions were chosen. The final approach is depicted in figure 2.

Fig. 2. Approach for the Development of Product-Service Systems.

In the following sections, the Approach for the Development of Product-Service Systems is presented. It consists of the five phases Planning, Development, Preparation, Market Performance and Replacement, as displayed in figure 2.

3.3. Planning

When a company initially develops a Product-Service System, it is necessary in most cases to conduct changes in the planning and the integrated realization of product and service development processes of the company to advance into the development of an integrated propose [3]. The first step of Planning is to analyze the customer requirements. A Product-Service System can only be successful on the market, when the requirements of the customers are met [11]. As a consequence, the environment and the requirements of the customers have to be determined and structured to build a business case [15]. The second step of Planning is to search for ideas for the Product-Service System. The service ideas are generated on the basis of customer needs, new service opportunities and conditions [16]. The same applies to the product, where the focus is set on searching existing solution and generating new solutions. The basic principle is to think in alternatives [19]. The generated ideas are prioritized and at the end of Planning, one idea is chosen [16].

The result of this phase is a detailed idea that determines the direction of the Development of the Product-Service System.

3.4. Development

The idea of Planning is further processed in the Development. In this step, the product and the service are developed alongside each other and for this the concept of the entire Product-Service System is defined by a carefully integrated chain of product and service offerings [1]. At the beginning of product development, the product structure is defined, the main characteristics of the main components are established and the main assemblies, the service concept and the manufacturing concept are created. In this step, alternative product concepts are generated and evaluated and a single concept is selected [11, 13]. In service development, the characteristics of the service have to be described, the processes for the conduction of the services are defined and the use of resources is planned [12]. The performance of the service and its desired results are described and a model of resources is designed [16]. Product and service have to be carefully coordinated to create a well-working, internally consistent Product-Service System [12].

The result of this phase is a Product-Service System that has reached the end of its development and fulfills the needs of the customers.

3.5. Preparation

The Preparation is conducted to secure the implementation of the Product-Service System in the way it is supposed to be. During the testing of the product, multiple preproduction versions of the product are constructed and evaluated. Alpha and beta prototypes are built to determine whether or not the product will work as designed and whether the production functions [13]. During service preparation, conceptional works are conducted in the company, organizational regulations have to be established and the training of coworkers is prepared [12, 16]. Changes that go with the introduction of the new service concerning processes, participants and physical facilities have to be assessed [18]. Means of assessment are established in this phase to secure the gradual improvement of the processes [14].

The result of this phase is a fully tested Product-Service System that is ready for Market Performance.

3.6. Market Performance

Before the Product-Service System can be offered to the customers, some units of the product have to be produced to fulfill the first demand. In the production ramp-up, the product is made using the intended production system with the purpose of training the work force and working out any remaining problems in the production processes [13]. Market launch is accompanied by final test activities and delivery of the required resources to the service employees. The start of the Product-Service System is monitored and its performance is reviewed [12]. As long as the Product-Service System

performs on the market, the product is produced and all activities are carried out to provide the service. The entire Product-Service System can be assessed during Market Performance to constantly improve it.

The result of this phase is a Product-Service System that has been successful on the market for a certain time.

3.7. Replacement

The Product-Service System has reached the end of its life-cycle in the Replacement. The product is not produced anymore and existing products are recycled [20]. The service is no longer offered on the market. This can lead to a new development process with a further development or a complete redesign [14].

The result of this phase is either the start of a new development or the retraction from the market. It is also possible that the phases overlap, as usual in practice.

4. Literature Review of Challenges and Methods

After the Approach for the Development of Product-Service System was completed, first expert interviews were conducted in an automotive company. The result was that most of the experts wished for a development process that does not only define the development phases, but also provides methods for every phase that support the developer. This opinion is also confirmed by other researchers. Meier et al. [9] state that alongside engineering and management, new methods and tools that make Product-Service Systems successful are required. The companies need new methods and concepts to design and develop Product-Service Systems [9]. Vasantha et al. [5] emphasize that in the process of transformation towards Product-Service Systems, industries require support in terms of tools, techniques and methods [5].

First the occurring problems and challenges during the development of a PSS were identified to gather the most suitable methods. This is due to the fact that methods are not applied for their own sake, but to solve concrete problems. This led to the third literature review, where at first problems or challenges were researched that occur especially in the development of PSS. In the second part of this literature review, methods were collected that have been developed especially for PSS or that have been used successfully with PSSs. In this literature review, the same search engines and the same search procedure were used, like in the first two reviews.

Table 4. Excerpt of challenges in the Planning.

Problem or Challenge	Reference
A social system or infrastructure that would accept or support the suggested Product-Service System scenario has to be found.	Mont [7]
It can be more difficult to identify the requirements of stakeholders of a Product-Service System.	Vasantha et al. [5]
The creation of proper business models is more difficult for Product-Service Systems.	Meier et al. [9]

The first result of this literature review was a list of 41 problems or challenges that could be allocated to the different phases. An excerpt of this list is shown in table 4 for the Planning phase. The second result of this literature review was a list of 25 methods that could be allocated to the different phases, too. For every method, a short description was created, exemplarily displayed in figure 3.

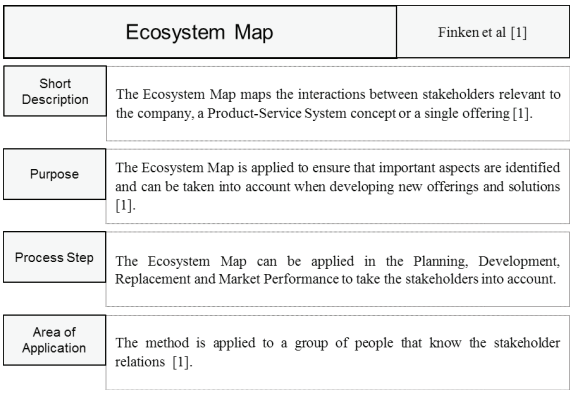

Fig. 3. Example of a method description.

This short description contains the four kinds of information. The “Short Description” gives an overview over the method and its possibilities. The “Purpose” explains reasons to apply the method. The “Process Step” shows in which process steps it is possible to use the method, and the “Area of Application” states which division can use the method. In the next step, the methods were assigned to the problems or challenges.

The occurring problems and methods of one phase were compared to each other and it was checked if one or more methods could solve a problem. As a result, 16 of the 41 problems or challenges could be matched with methods.

		Methods				
		Ecosystem Map	Product-Service Cross	Role by third Parties	TCO Chart	User Activity Cycle
Problems or Challenges	A social system or infrastructure that would accept or support the suggested product–service scenario has to be found [7].	✓		✓		
	It can be more difficult to identify the requirements of stakeholders of a Product-Service System [5].	✓		✓		✓
	The creation of proper business models is more difficult for Product-Service Systems [9].	✓	✓	✓	✓	

Fig. 4. Challenge matched with method in the Planning.

An excerpt of these matches in the Planning is displayed in figure 4. The benefit for the developer is that he can orient

himself on the approach during the development and if problems or challenges appear, he can check the list like the one in figure 4 and use a proposed method.

5. Use-Case: The Service Mobil

To illustrate the Approach for the Development of Product-Service Systems, an example in the automobile industry was chosen. Its purpose is to demonstrate that the development process of the Service Mobil (real name withheld) can be transferred into the abstract Approach. In reality, this PSS was developed without the knowledge of this approach. The Service Mobil is a Product-Service System that was introduced by an OEM in the automobile industry to improve the quality of the provided car, to increase the available mobility for the customer and as a consequence to increase the customer's satisfaction. It is a mobile service that was added to the manufactured cars to help the customers with problems. The customer buys the car and gets this service for free in the first two years. After Tukker [21], the Service Mobil is a product-oriented service. Since this is an already existing example, the information was reconstructed by expert interviews.

In the following paragraph, the phases during the development of the Service Mobil are explained and matched with the Approach for the Development of Product-Service Systems. In *Planning*, the developers detected that the customer requires mobility all the time. Furthermore, the development department of the cars stated that it needed a closer connection to the customer to improve quality. Consequently, a concept had to be developed to increase the customer's mobility and to reduce the distance between customer and the development. The Service Mobil was the idea that fulfilled the criteria best. In the *Development* it was figured out how the service could be added to the sold cars. The characteristics of the Service Mobil, like picking up a certain amount of equipment, were elaborated and proved to be applicable. Requirements for the personnel were 24h service, soft-skills and an education as experienced master. In the *Preparation* of the Service Mobil, tests were made to secure the practicability of the PSS, like the velocity of the service and the usefulness for the customer. To provide the infrastructure, the dealers were equipped with the Service Mobiles and the employees were trained for their mission. During the *Market Performance,* the cars are produced and the service is carried out. The customer is getting more mobility with his car and the development section is getting more information about current bugs. Since the Service Mobil is successful on the market, a *Replacement* is not planned yet.

After the development of the Service Mobil was presented earlier, the aim of this paragraph is to exemplary clarify the application of the methods, presented in the context of the Approach for the Development of Product-Service Systems. Due to the fact that the focus of this paper is set mainly on the development approach, not all of the 25 methods can be applied to the Use-Case. As an example for the application of the other methods, the *Ecosystem Map* is depicted in figure 5. This method maps the interactions between stakeholders relevant to the company, a Product-Service System concept or more specifically a single product or offering. The purpose of this method is to gain insights, which ensure that important aspects are identified and can be taken into account when new offerings and solutions are developed [1]. With the Ecosystem Map, the challenge "A social system or infrastructure that would accept or support the suggested product–service scenario has to be found." could be solved. This was actually a challenge, because it was not clear if the customers would accept a breakdown service of the OEM instead of a common breakdown service.

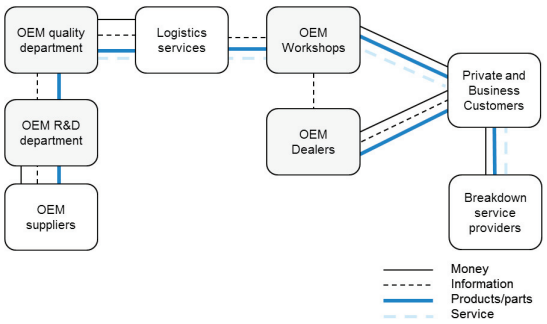

Fig. 5. The Ecosystem Map of the Service Mobil.

6. Discussion

In this chapter at first the use-case is discussed and later, the results of an expert survey are reflected upon. This survey was conducted in the same automotive company during this research.

6.1. Discussion of the Service Mobil

The discussion of the Service Mobil starts with the positive facts during its development. In the Planning, the initial ideas of the Service Mobil were presented. They are on a more abstract level of details and consequently, they can be displayed very well in this approach. In the Development, the detailed requirements are set. Some of them can be displayed in the Approach because they are visible in the Product-Service System on the market. Parts of the Preparation could also be displayed in the approach. An example for that is the training of the driver of the Service Mobil. The Market Performance is the phase that can be displayed best in comparison to the other phases, because much information about the functioning of the Service Mobil is available.

The central problem of the development of the Service Mobil was the access to the necessary information. In particular, in the phases Development and Preparation, the conducted actions of the company were nearly impossible to reconstruct. Also, Replacement can only be described when the Product-Service System has left the Market. Altogether, the information about the development process that can be provided by the Approach for the Development of Product-Service Systems is rather limited. In particular, the improvement of the development by using this approach could not be proved. However, the applicability of this

approach could be proven. To guarantee the applicability in a real development, the level of details of the Approach has to be increased.

6.2. Reflection of the Approach

During the research for this paper an expert survey was conducted to rate the approach. Seven experts of the automotive company had to answer a questionnaire anonymously. The experts stated that the attempt to create an approach for the development of products and services in combination may have a great potential for the future. Since Product-Service Systems are increasingly appearing in the industry, the demand for a guideline that supports the enterprise during the development will increase as well. Also, the practical relevance of such an approach is high.

The experts further stated that it would be helpful to present the phases with more details, to make the application of the approach easier. Rather concrete actions are easier to conduct than rather abstract ones, because they leave less room for interpretation. However, an approach with very concrete actions could also be very difficult to handle, because of its immense amount of provided information. Furthermore, a detailed approach can hardly be applied to different companies, because the innovation processes can differ greatly from each other.

7. Summary and Outlook

The aim of this paper was to create an Approach for the Development of Product-Service Systems. At first, the current approaches found in the literature review in this field of research were analyzed and regarded as insufficient. This led to the fact that the literature review had to be extended to the fields of product and service development. In these areas, models for the development of products and services were searched, in order to combine them to the Approach for the Development of Product-Service Systems. This approach was presented in chapter 3, extended by problems or challenges and methods and conducted with an examples in chapter 5.

In particular, the expert evaluation gave many hints for a further need of research and a further improvement of the Approach for the Development of Product-Service Systems. It was stated that an overview over the required time and effort of the respective phases could improve the approach, because it would give a basis for the planning of time and resources in the development process. In addition, the experts stated that a more detailed approach would be applicable easier in a company, because the actions that have to be carried out would be stated more clearly. The experts articulated not only their ideas for the improvement of the approach, but also their general expectations towards a development approach. The creation of a connection to the reality or the user-friendliness of the model and the benefits of this application was named as a basic point for the development. Since the experts stated the great importance of accompanying methods, a great potential would lay in the extension of the already collected methods.

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